·Clinical Research·

Use of the Crawford tube for symptomatic epiphora without nasolacrimal obstruction

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Abstract

• **AIM: To evaluate the effectiveness of the Crawford tube in treating symptomatic epiphora without nasolacrimal obstruction.**

• **METHODS: A protocol was adopted for the management of symptomatic epiphora without nasolacrimal obstruction. Patients who suffered symptomatic epiphora without nasolacrimal obstruction in both eyes were included in the study. One eye was treated with Crawford tube intubation and the other eye was treated with medication therapy. Degree of watering, patient satisfaction, and symptomatic improvement were carefully evaluated by one of the authors at the end of the follow-up period, after Crawford tube removal, to ascertain functional results.**

• **RESULTS: Thirty-seven adult patients (37 eyes) underwent Crawford tube intubation for functional epiphora. The mean follow-up time after removal of the tube was 14.8±4.8mo. The procedure was an overall success in 28 eyes (75.7%), with symptoms improving significantly. Two eyes (5.4%) were relieved of indoor epiphora, two (5.4%) had minimal epiphora outdoors, but only with wind or cold, and five (13.5%) continued to experience tearing both indoors and outdoors. Thirty of the patients (81%) expressed satisfaction with the procedure.**

• **CONCLUSION: Crawford tube insertion is an effective, safe, simple, and relatively noninvasive treatment strategy for functional lacrimal system obstruction.**

• **KEYWORDS:** Crawford tube; functional nasolacrimal duct obstruction; epiphora; lacrimal pump failure
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INTRODUCTION

Functional nasolacrimal obstruction (NLO), by definition [1-2], is epiphora without detectable obstruction of the lacrimal drainage system. The diagnosis of functional NLO is often based on a history of epiphora and patency to nasolacrimal syringing. Functional NLO is thought to be caused by a reduced contribution of the orbicularis oculi action and eyelid blinking to the lacrimal pump mechanism[1-2]. If the reduced pump mechanism is unable to overcome the natural resistance of the lacrimal outflow system, epiphora may result. Careful clinical examination helps to differentiate this factor from other causes, such as partial obstruction of the nasolacrimal duct, punctual stenosis, and paralytic ectropion.

The recommended management of lacrimal pump failure has been somewhat controversial. Some authors have reported that external dacryocystorhinostomy (DCR) is an appropriate surgical treatment for epiphora caused by functional NLO[3-8], while others have advocated less invasive silicone intubation (SI) as the first-line treatment in patients with functional NLO [8-16]. Previous studies [8-16] have reported good results using SI in incomplete NLO patients, with a success rate of 47%-79%. Unfortunately, some studies did not define functional NLO strictly, but they did demonstrate preoperative patency to syringing. A recent study [10] evaluated the efficacy of SI in strictly defined functional NLO. The researchers found an overall success rate of 77% in resolving epiphora symptoms, and they extrapolated the five- to six-year success rate at 50%. However, that study had an obvious limitation in that it did not include a control group. Thus, the purpose of the present study was to assess symptomatic outcomes with the Crawford tube in patients with "functional block", using the fellow eye as a control.

SUBJECTS AND METHODS

Subjects Patients with functional NLO presenting to the Eye Center, the Second Affiliated Hospital of Zhejiang University School of Medicine, between January 2011 and January 2013 were assessed by an ophthalmologist for their suitability for the Crawford tube insertion approach. Adult patients with bilateral epiphora, nasolacrimal systems freely patent to irrigation with no reflux from the opposite canaliculus or punctum, and absence of alternative etiology for epiphora were included in the study. Exclusion criteria included complete NLO, dacryocystitis, canaliculitis, dacryoliths, punctal stenosis, canalicular stenosis, eyelid laxity, punctal ectropion, lagophthalmos, significant dry eye, ocular surface disease, facial palsy, lacrimal hypersecretion,

trauma, or surgery history of the lacrimal system. This study was approved by the Ethics Committee of the Second Affiliated Hospital of Zhejiang University School of Medicine of China, and it complied with the tenets of the Declaration of Helsinki. Informed consent was obtained from all of the patients after they received an explanation of the nature and possible consequences of the procedures.

Methods A standardized syringing technique[10] was used in all cases to determine a patent lacrimal drainage system. After instillation of a topical anesthetic, a 23-gauge cannula attached with a 5 mL glass syringe was inserted vertically in the ampulla and then passed gently through the lower lacrimal canaliculus, until a "hard stop" was felt in the lacrimal sac. The cannula was withdrawn 1 mm and gentle irrigation was performed with saline fluid. If there was no significant resistance while passing the cannula and a "hard stop" was identified, and if there was no reflux of fluid from the upper or lower canaliculus, the case was considered a true functional NLO. Clinical examination data included age, sex, timing of Crawford tube removal, follow-up time, and potential surgical complications.

The decision regarding which eye would be treated with Crawford tube intubation was based on the symptoms of the eyes. Degree of watering was evaluated and classified according to the following clinical symptoms: 1) no epiphora; 2) minimal epiphora outdoors, but only with wind or cold; 3) troublesome epiphora outdoors, but not indoors; 4) epiphora indoors and outdoors. Eyes with preoperative tearing symptoms classified as 3) or 4) received the tube intubation procedure. The epiphora of the severe eye was selected as the surgery eye. The right eye was chosen if the symptoms were similar in both eyes.

All surgical procedures were performed by a single experienced specialist in lacrimal surgery. A management plan was devised for the eyes with lacrimal intubation with a silicone Crawford tube (Bausch & Lomb Freda) (Figure 1). The surgical procedures were described previously [17]. Briefly, lacrimal intubation of the Crawford tube was performed under topical anesthesia with 0.4% oxybuprocaine hydrochloride (Santen Pharmaceutical Co., Ltd.). The inferior nasal meatus was treated with a pledget soaked in 0.4% oxybuprocaine hydrochloride and 1% ephedrine hydrochloride solution. First, a dilator was used to dilate the lacrimal puncta, after which a probe was used to probe the nasolacrimal duct through both the upper and lower puncta. A silicone Crawford tube was passed from both the lower and upper puncta to the nasolacrimal duct (Figure 2A) and out of the nose (Figure 2B). The two ends were tied beside the nose, the excess tubing was cut off, and the endpoint was left in the inferior nasal meatus for three to six months. Figure 3 shows the position of silicone Crawford tube after lacrimal intubation.

Postoperatively, the patients were administered 0.5% levofloxacin eye drops (Santen Pharmaceutical Co., Ltd.) four times per day and 0.5 g oral levofloxacin tablets

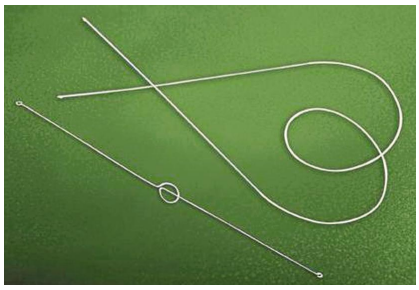

Figure 1 Crawford tube used in our study.

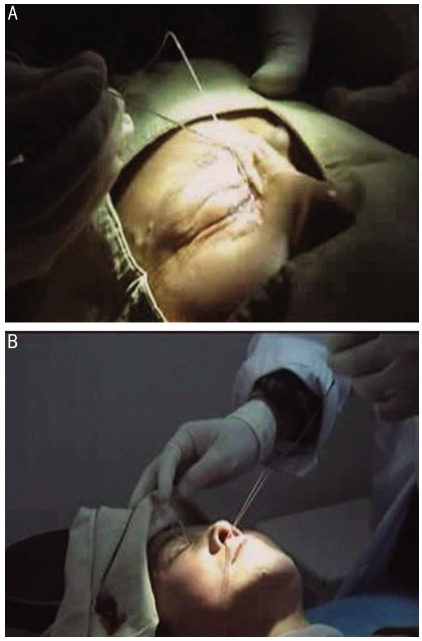

Figure 2 The procedure of lacrimal intubation with Crowford tube A: A silicone Crawford tube was passed from both the lower and upper puncta to the nasolacrimal duct; B: A silicone Crawford tube was pulled out of the nose.

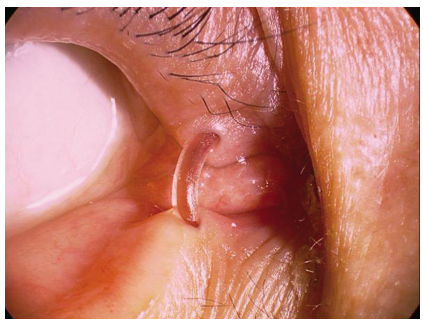

Figure 3 The position of Crawford tube after lacrimal intubation.

(Daiichi Pharmaceutical Co., Ltd.) once per day for four days. Follow-ups occurred at one day, one week, one month, three months, and six months. In the majority of cases, the Crawford tubes were removed at the six-month follow-up. All of the patients completed at least eight months of follow-up after the Crawford tube was removed. The fellow eyes were placed on a one-month taper of tobramycin and dexamethasone (TobraDex; Alcon) ophthalmic drops unless contraindicated.

Degree of watering, patient satisfaction, and symptomatic improvement were carefully evaluated by one of the authors

(Tong NX) at the last followup after Crawford tube removal to ascertain functional results. The patients were asked to quantify their symptoms as follows: 1) no resolution, severe epiphora is the same or worse; 2) partial resolution, substantial subjective improvement of epiphora, no further procedure required (*e.g.* reintubation or DCR); or 3) full resolution, complete absence of tearing or minimal epiphora, both indoors and outdoors.

Statistical Analysis Statistical analysis was performed using SPSS software version 12. A nonparametric Wilcoxon signed-rank test (with continuity correction) was used for the statistical analyses. *P* values <0.05 were considered statistically significant.

RESULTS

Thirty-seven patients (8 men and 29 women) with a mean age of 52.8±9.0y (range, 41-68y) were included in the study. The patients' baseline data is presented in Table 1. The Crawford tube was removed after 5.1 ±1.2mo (range, 3-6mo). The mean follow-up interval after removal of the Crawford tube was 14.8±4.8mo (range, 8-25mo).

At the last follow-up, resolution of symptoms occurred in 28 eyes that underwent Crawford tube intubation. Two eyes were relieved of indoor epiphora, two eyes had minimal epiphora outdoors, but only with wind or cold, and five eyes continued to experience tearing both indoors and outdoors. Thirty of the patients expressed satisfaction with this procedure. Two patients noted improvement of epiphora with the tube in place but deterioration after removal of the tube. There were no significant intraoperative or postoperative surgical complications. However, resolution of symptoms only occurred in two of the fellow eyes, and three of the fellow eyes experienced partial resolution of epiphora, indoors or outdoors. The results demonstrate that treatment with Crawford tube intubation can significantly improve epiphora in cases of functional NLO (χ^2=17.102, *P*=0.000) (Table 2).

Table 1 Baseline characteristics

Variables	All data
Patients	37
Age ($\bar{x} \pm s$, a)	52.8±9.0
Gender (M/F, *n*)	8/29
Crawford tube intubation eyes (OD/OS)	21/16
Time until tube removal ($\bar{x} \pm s$, mo)	5.1±1.2
Duration of follow-up after removal of tube ($\bar{x} \pm s$, mo)	14.8±4.8

Table 2 Epiphora improvement results

Resolutions	Tube intubation eyes	Fellow eyes	*P*
Full resolution	28	2	<0.05
Partial resolution	4	3	>0.05
No resolution	5	32	<0.05

DISCUSSION

The treatment of lacrimal pump failure is controversial. In the past, functional NLO was commonly treated by external DCR [3-8]. Although external DCR often has a high success rate of over 90%[6,8] and leads to symptomatic improvement, it can also lead to complications such as skin scarring, cerebrospinal fluid leakage, and prolonged surgical time. Some experts have recommended DCR as an initial management for functional NLO, whereas others have argued that external DCR can potentially temporarily disrupt the orbicularis, resulting in poor functioning of the lacrimal pump[8,18]. Chan *et al*[1] classified the functional abnormalities into two levels: pre-sac and post-sac block. A previous study [19] showed that patients with post-sac block have good DCR outcomes, while patients with pre-sac block have poorer results. Those findings suggest that DCR might improve symptoms in most patients with post-sac "functional block" , and that the persistence of epiphora in some patients might be due to the likely role of pre-sac block. Intubation might increase the volume of the entire outflow system and thus, overcome both pre-sac and post-sac "functional block" . This indicates that surgeons could choose intubation as a first treatment for functional NLO.

In recent years, these tubes have been shown to benefit persistent epiphora with a patent lacrimal system[8-16]. There is increasing evidence in the literature of the beneficial effects of intubation in functional NLO patients. A previous series[9-10] showed that intubation was successful in patients with a diagnosis of functional obstruction, with the success rate ranging from 47% to 79%. However, other causes, such as punctual stenosis and canalicular obstruction, were not excluded in these studies. A recent study[10] reviewed 44 eyes of 30 patients who underwent SI for persistent epiphora due to functional NLO. The researchers reported resolution of symptoms in 77% and no improvement in 22.7% of the eyes after a mean follow-up of 2.6y. However, that study did not include a control group. In our study, we found that 75.7% of the eyes experienced significant improvement in tearing following Crawford tube insertion for the treatment of functional NLO, using the other eye as a control. Our results are similar to the 77% success rate reported by Moscato *et al* [10]. It appears that SI can significantly alleviate tearing in patients with lacrimal pump failure. The purpose of the Crawford tube is to reconstitute the natural lacrimal pathway. Insertion of the tube is quick, noninvasive, relatively painless, and generally without significant risk to patients, thereby offering a significant advantage compared with the more invasive DCR. The positive outcomes of this study suggest that this relatively noninvasive procedure could result in a high success rate for functional NLO that approaches that of DCR.

Epiphora caused by facial palsy can occur as a result of many factors. Surgical operations, such as correction of lower lid malposition, can address most cases of epiphora due to facial palsy [20-23]. However, some patients continue

tearing after effective correction of lid malposition, which could be due to continued paralysis of the orbicularis oculi muscle, leading to impairment of the canalicular pumping action. Previous studies [23-24] have used Jones bypass tubes to manage epiphora in patients with continued epiphora with patency of the drainage system after successful eyelid surgery to correct punctal malposition and to address lid laxity. Those authors found that 72.2% -83.3% of eyes experienced significant improvement in tearing following insertion of the Jones tube, a figure not significantly different from the 75.7% success rate in our study. However, complications such as tube extrusion and malposition were common with the Jones bypass tubes [24]. In contrast, there were almost no complications in our study of the Crawford tube. We suggest that Crawford tube insertion might be more effective and safer than Jones tube insertion in this set of patients. Future clinical studies are needed to test this hypothesis.

Involutional eyelid changes over time result in orbicularis oculi weakness, leading to decreased pump hydrostatic pressure [18], which is insufficient for adequate flow. Intubation might dilate the mucosal tissue portion of the nasolacrimal system and potentially increase the outflow volume, thereby resulting in increased flow. This is a possible mechanism by which the Crawford tube might improve epiphora in the presence of lacrimal pump failure. Interestingly, in this study, two patients noted improvement of epiphora with the tube in place and deterioration after tube removal. Capillary action might explain the flow of tears around the tube and into the nose.

In conclusion, Crawford tube insertion is a minimally invasive technique with a high success rate in relieving epiphora in patients with functional NLO. Our results suggest that this methodology can be safely considered as a primary procedure in patients with functional NLO.

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